P-23 Low Energy Neutron Team

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About the NPDGamma Experiment

$$\vec{\mathbf{n}} + \mathbf{p} \rightarrow \mathbf{d} + \gamma$$

P-23 Group Meeting / April 18, 2002

The NPDGamma Experiment at Los Alamos NATIONAL LABORATORY

LANSCE is the only facility worldwide that can host this nuclear physics experiment.

NPDGamma is under construction and will begin data collection in 2003.

Measurement of the Parity-Violating Gamma Asymmetry A_γ in the Capture of Polarized Cold Neutrons by Para-Hydrogen, $\vec{n} + p \rightarrow d + \gamma$

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http://p23.lanl.gov/len/npdg/

What is NPDGamma measuring?

The laws of physics describe four interactions:

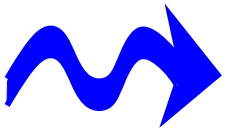
gravity

electromagnetism

strong force

weak force

The strong force binds hadrons together, and is the primary interaction between protons and neutrons.



The weak interaction between hadrons

(i.e. protons and neutrons)

is not well-measured or understood.

How do we study the hadronic weak interaction?

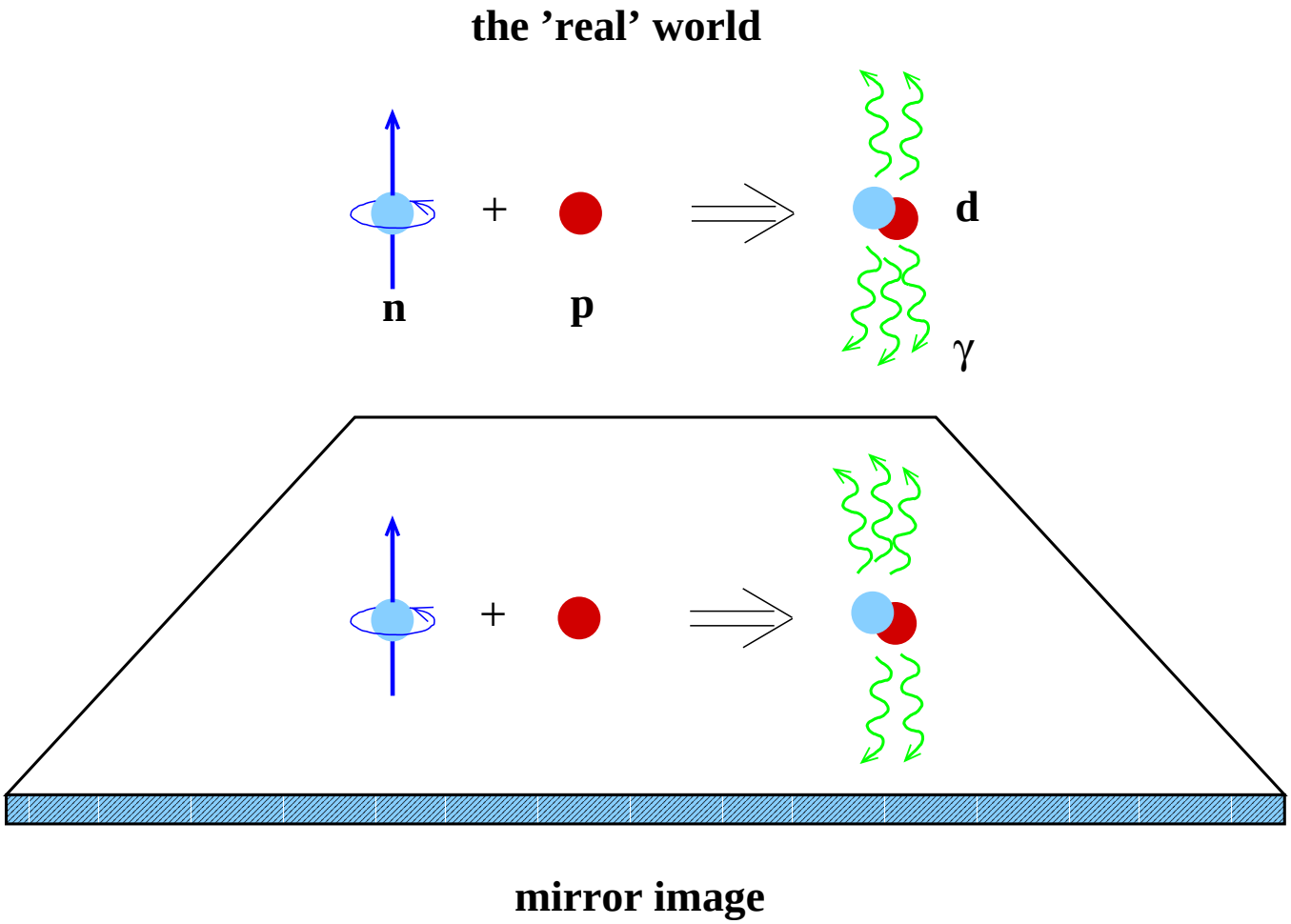
To see its sometimes very small effects, a powerful technique is to use parity violation.

force	strong	weak
strength	$\sim 10^6$	1
parity?	conserved	violated

(Necessary to observe $\Delta s = 0$, nonleptonic weak interactions.)

$\vec{n} + p \rightarrow d + \gamma$ (2.2 MeV)

NPDGamma will measure A_γ, the parity-violating asymmetry in the distribution of emitted γ's



If the up/down γ rates differ, parity is violated (PV $\longrightarrow$ signature of the weak interaction)

Expected asymmetry $\approx 5 \times 10^{-8}$

Goal experimental error: 0.5×10^{-8}

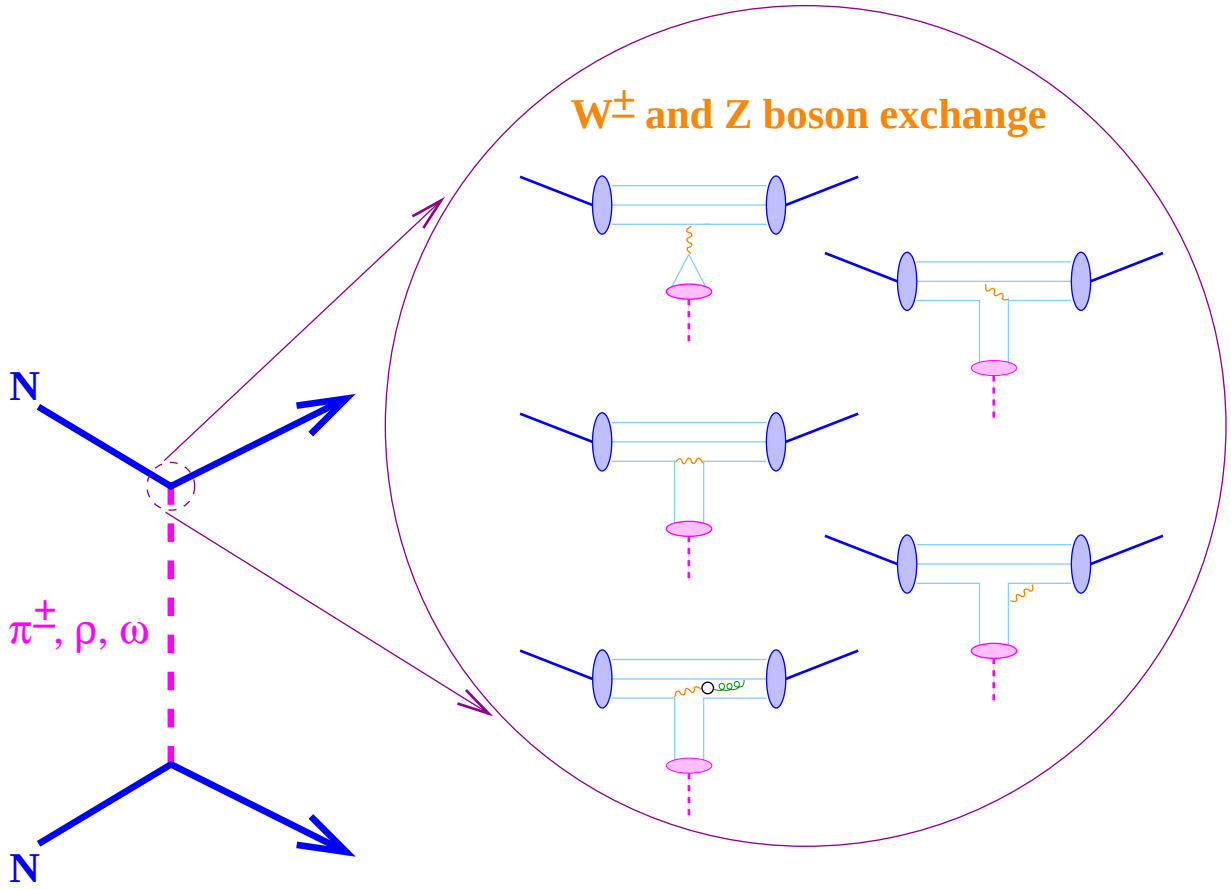
Range of Z, W^+, W^- bosons is 0.002 fm

But nucleon interactions take place
on a scale of 1 fm (short range repulsion)

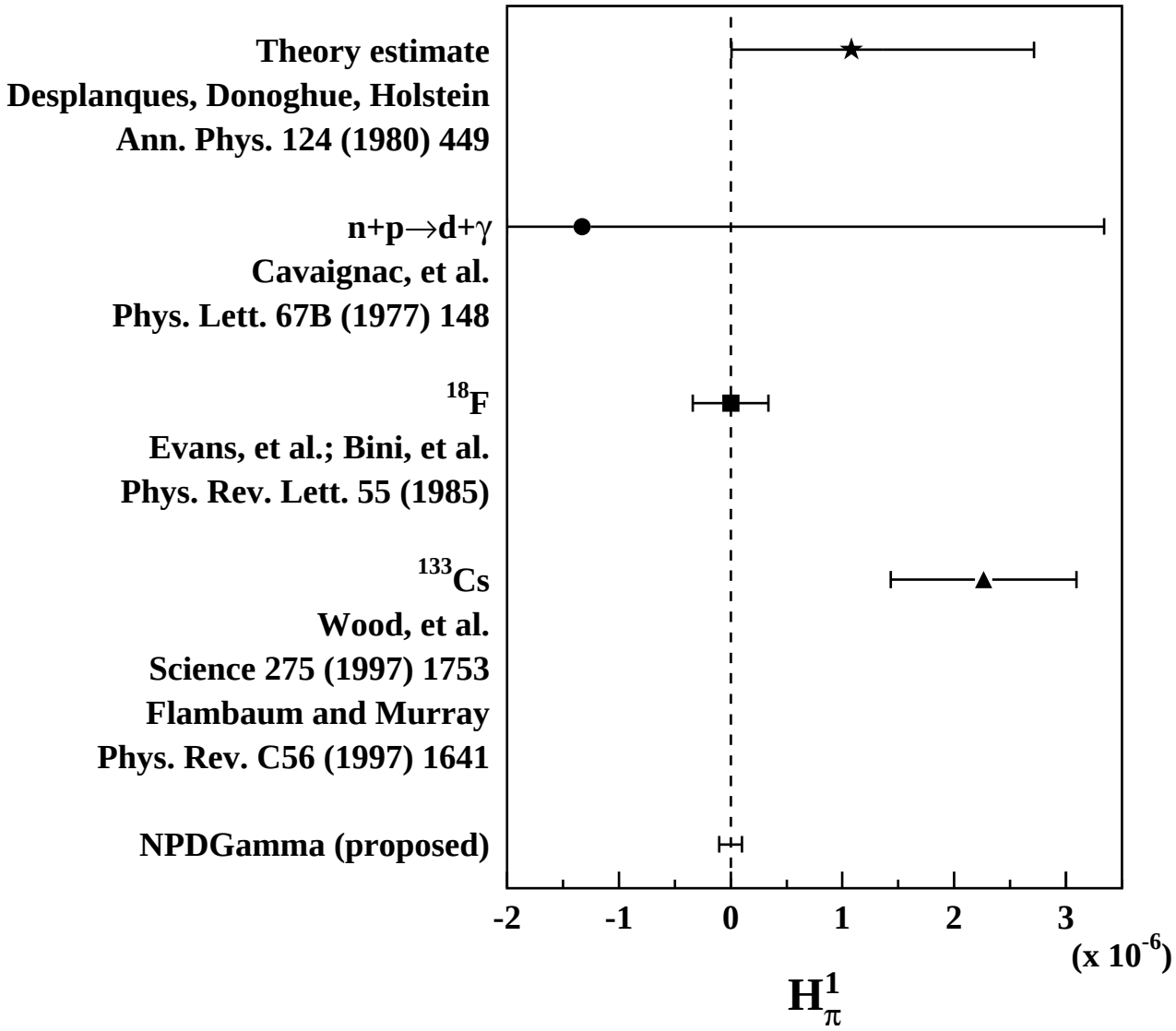
the weak force interaction between
nucleons and hadrons is a meson exchange

At low energies (< 300 MeV)
mesons are the appropriate degree of freedom

Meson exchange model is a successful picture of strong interactions between nucleons (describes to a few % n-p/p-p scattering cross-sections)



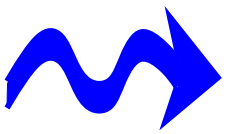
A_γ is a clean measurement of H_π^1: $A_\gamma \approx -0.045 H_\pi^1$



NPDGamma will provide a measurement with improved statistical precision compared to ^{18}F results, with no uncertainties from many-body calculations or nuclear structure effects.

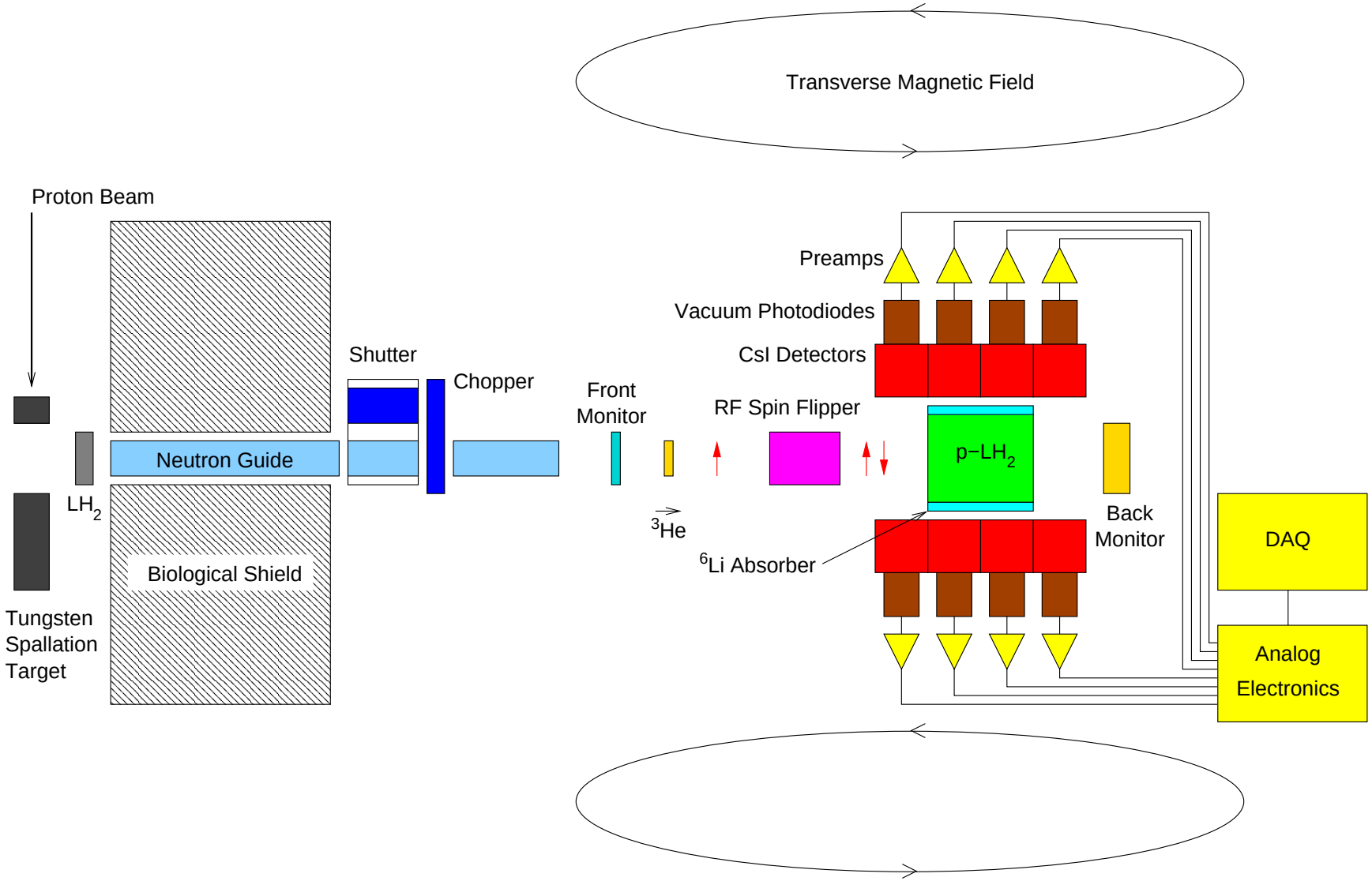
What does NPDGamma need?


lots of polarized cold neutrons


protons


γ detectors

NPDGamma Experimental Setup

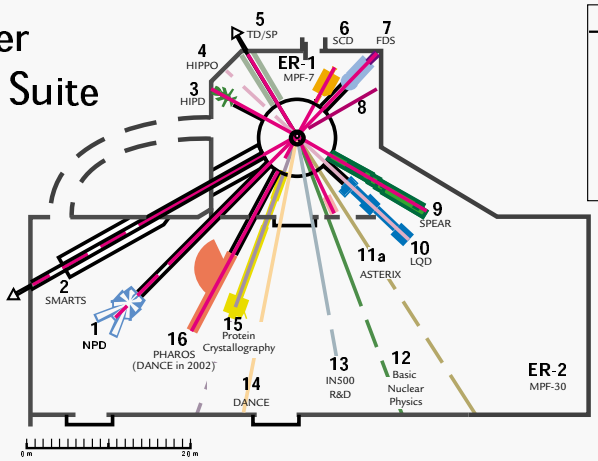


NPDGamma is a funded experiment ($4.8M)

DOE & NSF

also Hamilton College, Indiana University, KEK, University of Manitoba, University of Michigan, NIST, University of New Hampshire, TJNAF

Lujan Center Instrument Suite



Moderators
1, 2, 16: high-resolution H_2O decoupled
3, 4, 5: high-intensity H_2O decoupled
6, 7, 8: high-intensity H_2O decoupled
9, 10, 11: $\mathcal{L}H_2$ @ 20 K partially coupled
12, 13: $\mathcal{L}H_2$ @ 20 K coupled
14, 15: H_2O coupled

FP1 **Neutron Powder Diffractometer (NPD)** allows for studies of complex structures, internal strain measurements, and phase transformation.
Don Brown, 505-667-7904, dbrown@lanl.gov

FP2 **Spectrometer for Materials Research at emperature and Stress (SMAR S)** will allow measurements of spatially resolved strain-fields, phase deformation and load transfer in composites, the evolution of stress during temperature (or pressure) fabrication, and the development of strain during reactions (such as reduction, oxidation, or other phase transformations).
Mark Bourke, 505-665-1386, bourke@lanl.gov

FP3 **High Intensity Powder Diffractometer (HIPD)** is designed to study the atomic structure of materials that are available only in polycrystalline or noncrystalline forms.
Robert Von Dreele, 505-667-3630, vondreele@lanl.gov

FP4 **High-Pressure-Preferred Orientation (HIPPO)** instrument is a new high-intensity powder diffractometer for high-pressure and texture measurements.
Kristin Bennett, 505-665-4047, bennett@lanl.gov and Robert VonDreele, 505-667-3630, vondreele@lanl.gov

FP5 **FP5** is used to study the Doppler shift and broadening of low-energy nuclear resonances in materials under extreme conditions and for structural studies using transmission Bragg diffraction.
Vincent Yuan, 505-667-3939, vyuan@lanl.gov

FP6 **Single Crystal Diffractometer (SCD)** has been used to study the structure of organometallic molecules, unique binding of H_2 crystal structure changes at solid-solid-phase transitions, magnetic spin structures, twinned or multiple crystals, and texture.
Yusheng Zhao, 505-667-3886, yzhao@lanl.gov

FP7 **Filter Difference Spectrometer (FDS)** is designed to determine energy transferred to vibrational modes in a sample by measuring the changes in the energies of the scattered neutrons.
Juergen Eckert, 505-665-2374, juergen@lanl.gov

FP9 **Surface Profile Analysis Reflectometer (SPEAR)** is used with an unpolarized neutron beam to study solid/solid, solid/liquid, solid/gas, and liquid/gas interfaces.
Greg Smith, 505-665-2842, gsmith@lanl.gov and Jaroslaw Majewski, 505-667-8840, jarek@lanl.gov

FP10 **Low-Q Diffractometer (LQD)** is designed to study structures with dimensions in the range from 10 to 1000 Å. It measures a broad Q-range in a single experiment without physical changes to the instrument.
Rex Hjelm, 505-665-2372, hjelm@lanl.gov

FP11a **AS ERIX** will provide a polarized neutron beam for studies of magnetic materials, using reflectometry and diffraction, and includes application of high magnetic fields.
Mike Fitzsimmons, 505-665-4045, fitz@lanl.gov

FP12 **FP12** will be used for a fundamental nuclear physics experiment to precisely measure the asymmetry of the emission of gamma rays from the capture of polarized neutrons by protons.
David Bowman, 505-667-7633, bowman@lanl.gov

FP13 **IN500** is a protoype instrument under development employing novel techniques to enhance inelastic cold-neutron spectroscopy at spallation neutron sources.
Margarita Russina, 505-667-8841, russina@lanl.gov Ferenc Mezei, 505-667-7633, mezei@lanl.gov

FP14 **Detector for Advanced Neutron Capture Experiments (DANCE)** will be used for the study of neutron capture on radioactive nuclei in support of the stockpile stewardship program and for nuclear astrophysics.
John Ullmann, 505-667-2517, ullmann@lanl.gov

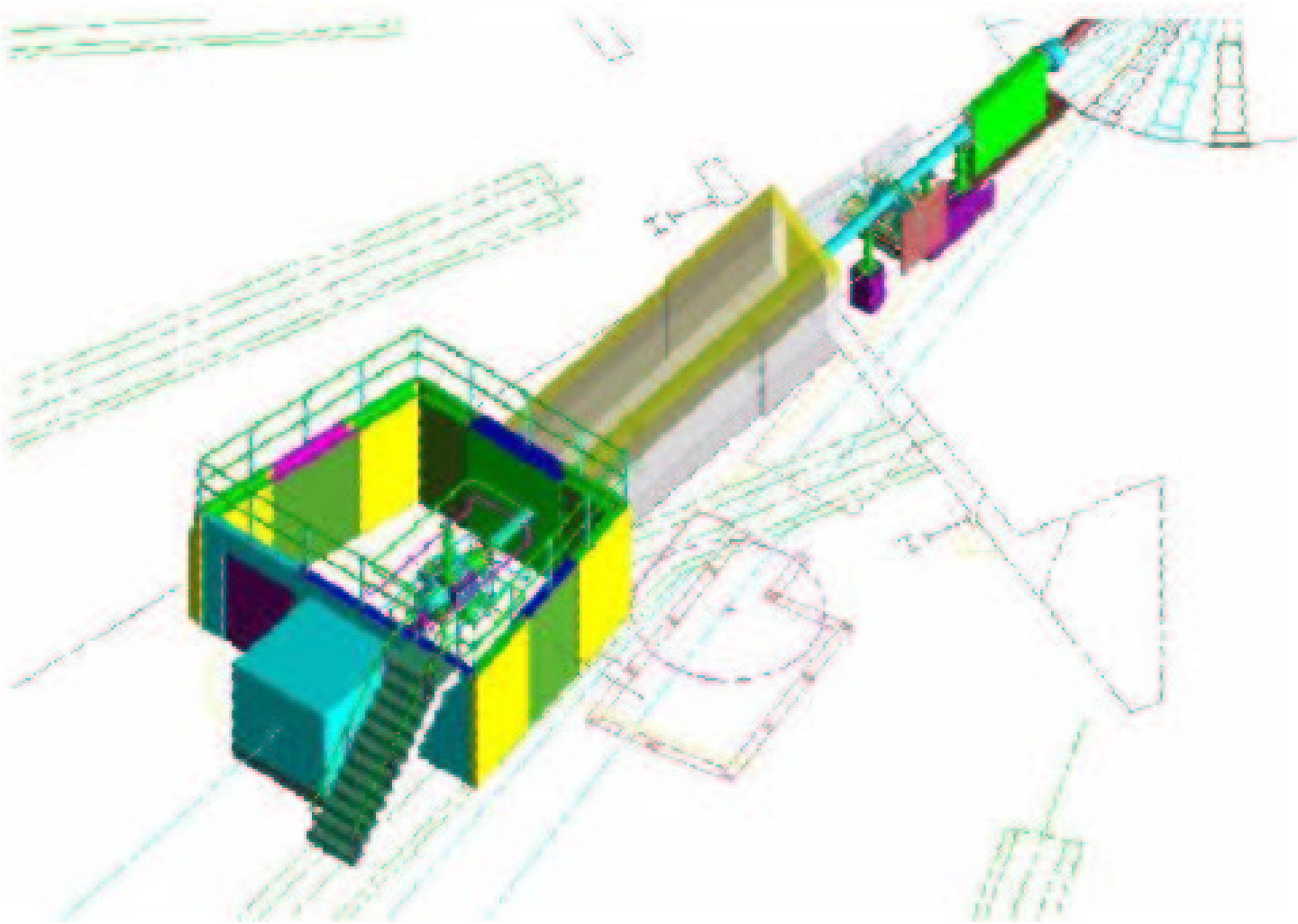
FP15 **Protein Crystallography Station (PCS)** is a single-crystal diffractometer designed for structure determinations of large biological molecules.
Paul Langan, 505-665-8125, langan_paul@lanl.gov Benno Schoenborn, 505-665-2033, schoenborn@lanl.gov

FP16 **PHAROS** is a high-resolution chopper spectrometer designed for studies of Brillouin scattering, magnetic excitations, phonon densities of state, crystal-field levels, and chemical spectroscopy and measurements of $S(Q,\omega)$.
Robert McQueeney, 505-665-0841, mcqueeney@lanl.gov

NPDGamma building FP12 to be ready for:

commissioning run Fall 2002

production data taking 2003



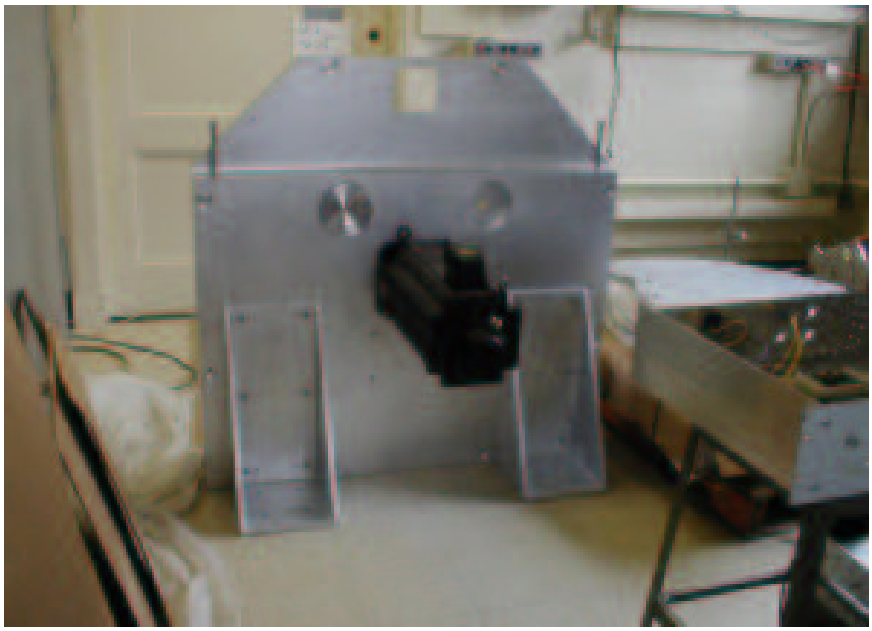
(MOU between LANSCE and P Divisions)

Flight Path 12 Construction Progress

in-pile guide

shutter

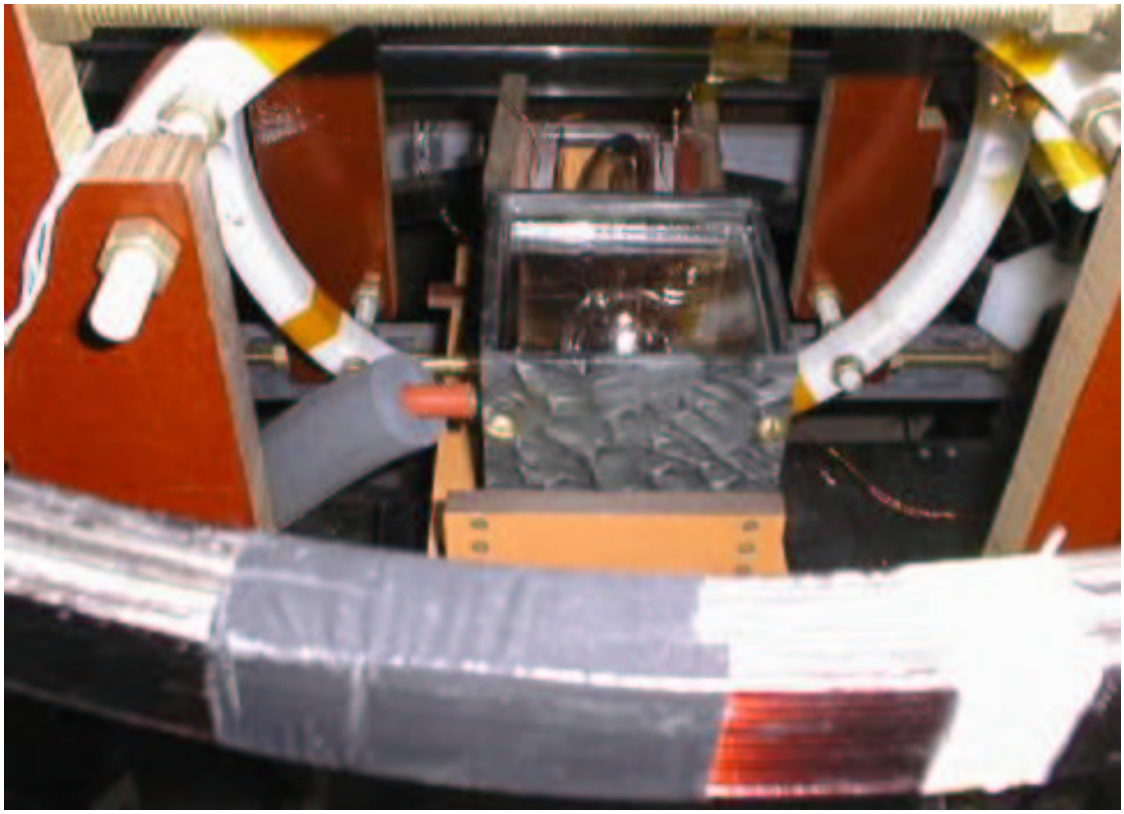
frame overlap chopper



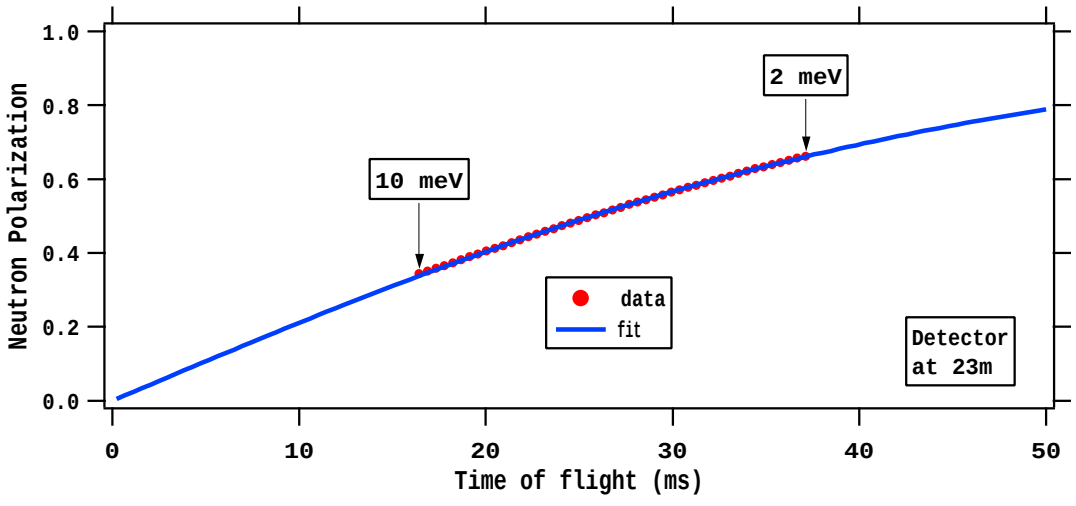
^{3}He Spin Filter

Optical pumping of Rb vapor, which polarizes ^{3}He by hyperfine spin-exchange collisions.

Neutron beam is polarized by passing through the cell. Antiparallel spin neutrons are absorbed.

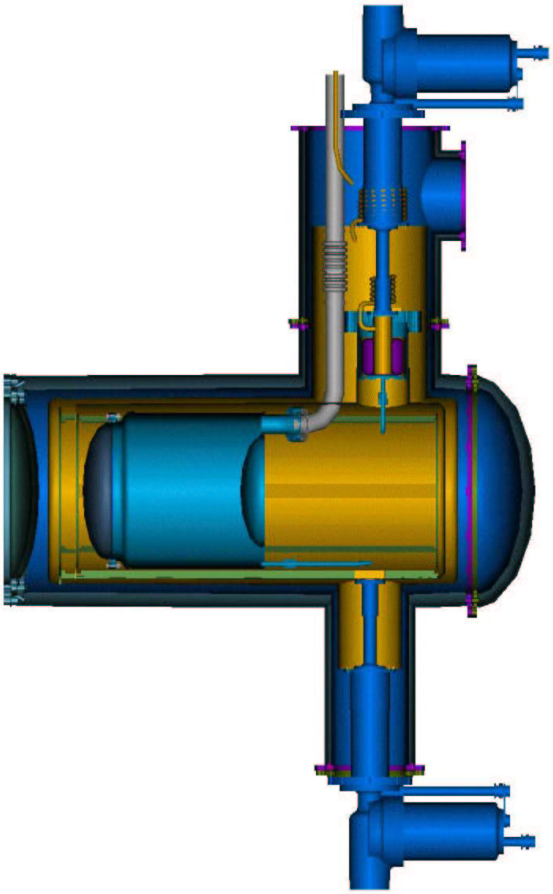


Fall 2000 Test Run: ^{3}He polarization of 26.5% $\longrightarrow$ n polarization of 30-70% for 2-10 meV



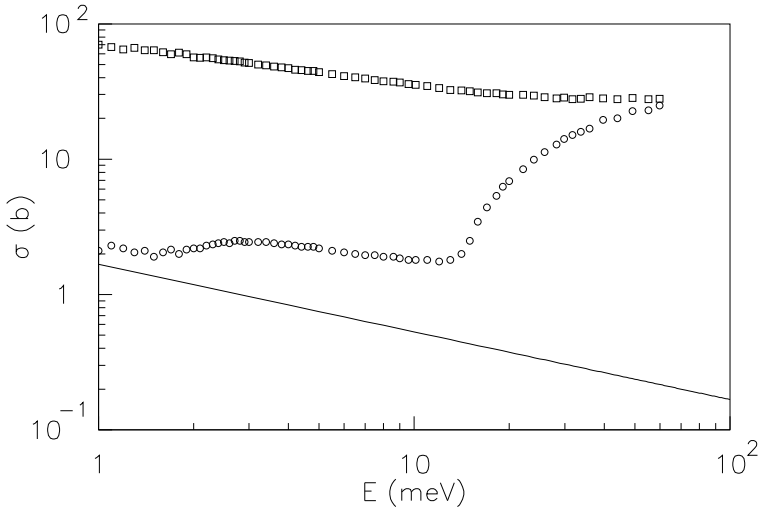
Liquid para-hydrogen target

20 ℓ, Mg-Al cryostat window, ^{6}Li liner



n cross-sections: ortho- ($\uparrow\uparrow$) and para- ($\downarrow\uparrow$) hydrogen

□ ortho- scattering, ∘ para- scattering, – np capture

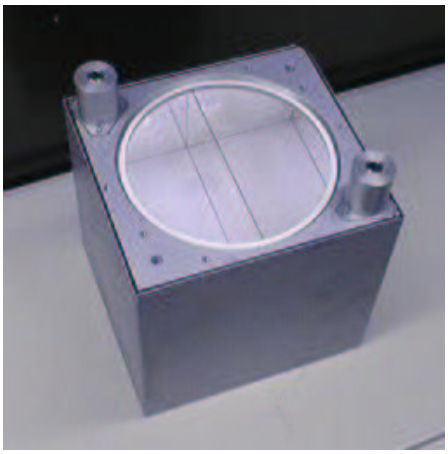


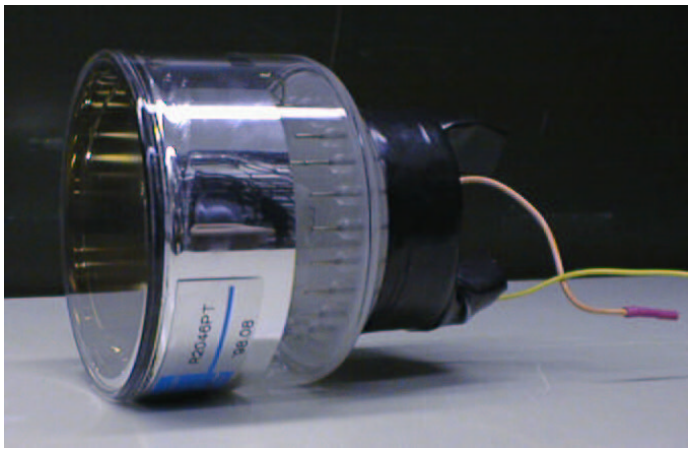
at 17K, ortho- fraction is 0.03%

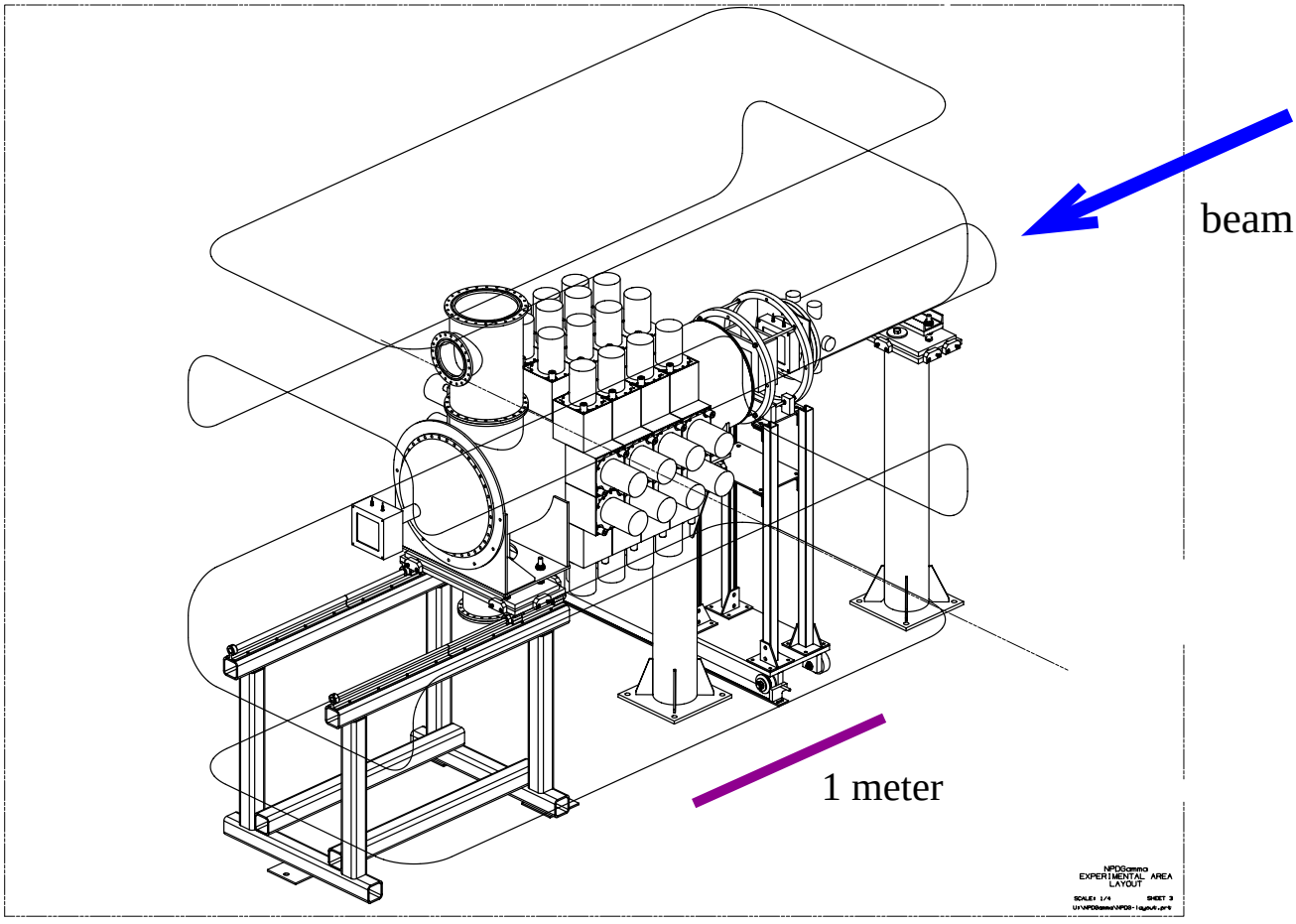
Para-hydrogen: necessary to allow neutron capture and to preserve neutron polarization upon scattering

CsI(Tl) and Photodiode γ Detectors

48 of these detectors will be used in the full experiment

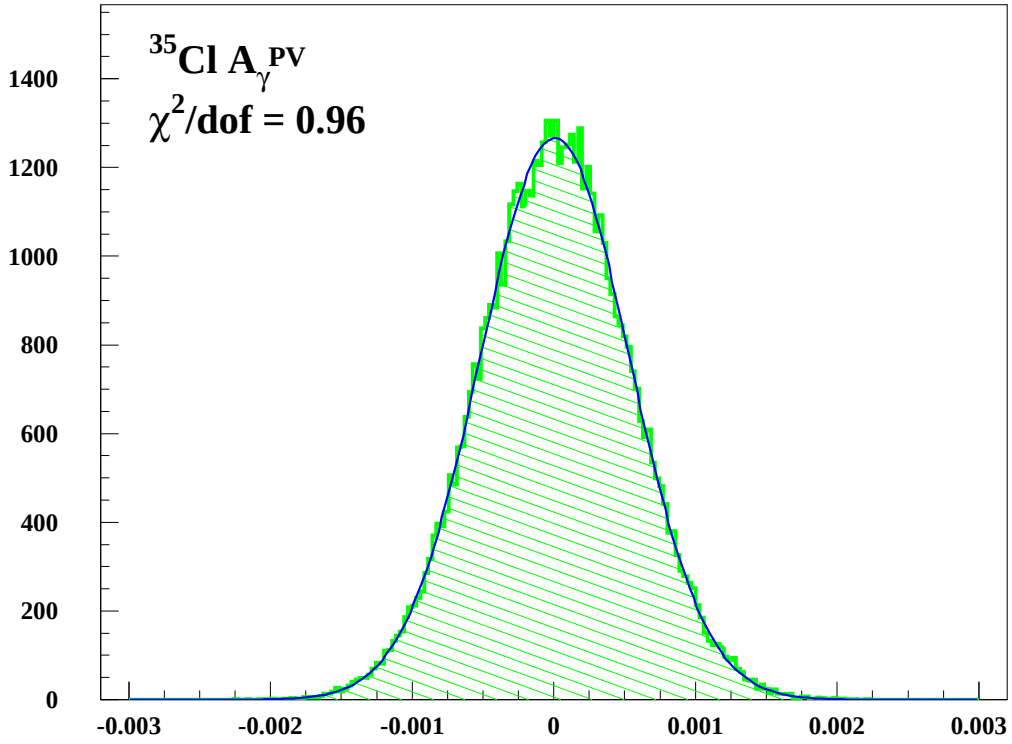






PV Asymmetry Measurements on Cl, La, Cd

Test Run Fall 2000



Raw PV Asymmetries ($\times 10^{-6}$)

^{35}Cl	-7.68 ± 2.17
^{139}La	-5.88 ± 2.35
^{113}Cd	$+1.94 \pm 1.48$

Physics Asymmetries A_γ ($\times 10^{-6}$)

	^{35}Cl	^{113}Cd	^{139}La
Leningrad	-27.8 ± 4.9	-1.3 ± 1.4	-17.8 ± 2.2
ILL	-21.2 ± 1.7	-	-
LANSCE	-23.1 ± 6.5	$+5.8 \pm 4.4$	-17.1 ± 6.8

(LANSCE results to be published.)

NPDGamma Status

- FP12 flight path is under construction.

- Experiment is under construction.
  10% scale apparatus tested Fall 2000.
  Alignment scheme & monitors tested Fall 2001.
  All crucial components demonstrated.

- Test runs indicate design is sufficient for target A_γ experimental error, 0.5×10^{-8}.

- Potential systematic errors studied extensively.

- NPDGamma will make a clean measurement of H_π^1, the most fundamental weak N-N coupling.

NPDGamma Schedule

January 2002	Start beamline installation
November 2002	Commission beamline through ER1
January 2003	Installation of guide complete
June 2003	FP12 Commissioning Run
August 2003	Commission entire experiment
Fall 2003	Begin data taking
December 2003	Data match existing stat. precision on H_π^1
2004 / 2005	Continue data taking for 10% measurement